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SMALL WIND-ELECTRICAL INSTALLATIONS FOR EXPORT

G. R. Seidel *

Overland networks for energy supply of remote and low density urban areas are uneconomical. This is especially true for the large farming areas in the United States and Canada, the colonial regions in Africa and South America, the Orient and even some parts of rural Europe. This is why electricity for lighting is still not known in many areas. It is inconvenient to produce the power by generators with combustion motors. This is also expensive and requires manual operation, a number of accumulator batteries and often fuel must be obtained from far away supply points. However, wind is available almost everywhere. This is why there is nothing like the small wind-electric installations for low level power generations, with the exception of small water generating stations. These require no maintenance, are very economical. /158**

The success with water turbines for the production of drinking water in colonial areas has led to the development of wind turbines for electrical power production [1]. The technical effort for wind turbines are sometimes substantial and the electrical problems are not always solved in a satisfactory way. This is why these experiments were terminated.

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** Numbers in the margin indicate pagination of original foreign text.

Instead, in the United States, two or three bladed propeller-type wind-wheels have been developed and equipped with small current generators. At the beginning they were used to power radio batteries and later on to power lighting systems.

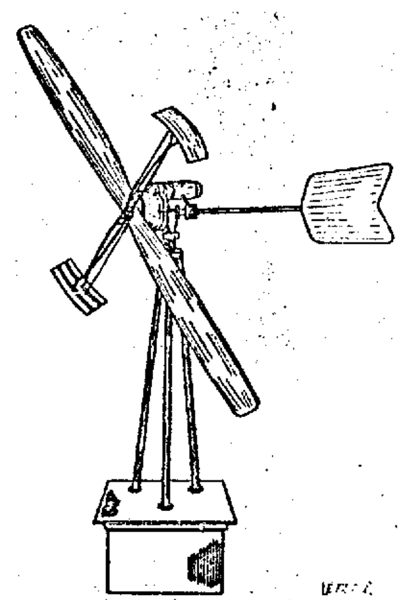

Figure 1. American wind charger with brake flaps

The Wind Charger

The thin blades of the wind chargers, usually made of wood, used a gear transmission. A high rotation rate generator is used to produce a low voltage. These are not propellers like those used on an aircraft as has often been stated. They are calculated according to the momentum theorem to obtain favorable energy exploitation from the wind, just like in other wind-wheel constructions. The main feature of the wind charger blade wheel is the high rotation rate. The circumferential velocity of the blade tips is between six and ten times the wind velocity. This is why the blades are so thin. The blades of the wind chargers operate at low wind velocities with very unfavorable aerodynamic conditions. The reason for this is the similarity laws of the flow. The viscosity properties of the air become more unfavorable when the "pitch rate" defined as the product of the flow velocity and the body length subjected to the flow (blade chord here), is reduced. /159

In order to increase the economy and to use the device with smaller wind velocities, it is necessary to select somewhat larger wind wheels having lower rotation rates (larger blade areas).

The Blade Wind Generation Station

The "blade wind generation" probably is best suited for this test. Bilau is certainly the first person to equip one of the first wind generation stations with profiled blades similar to lifting wings. He took advantage of the knowledge which was developing in aerodynamics due to the rise of aircraft. Using the "rotating wings" he obtained higher efficiencies than those of windmills and wind turbines [2]. Almost all modern wind generation plants are based on this fundamental idea.

Operational and Control Problems

The operational conditions when a direct current dynamo is driven by a wind-wheel are best understood by considering the interaction of the characteristic lines (Figure 2). The characteristic lines of the wind-wheel are determined using affinity laws, according to which the power increases according to the third power of the wind velocity, and the rotation rate increases in proportion to the wind velocity. Since the rotation rate is not related to the characteristic line of the dynamo in any way, it must appear as a parameter in the representation. This is why for each wind velocity a special curve is obtained. Because of the particular nature of the dynamo characteristic line according to which it increases steeply only beginning at a certain rotation rate, a decision must be made whether one wishes to take advantage of weak winds with a good efficiency or of strong winds with a poor efficiency. One can also decide to exclude weak winds entirely and instead to use strong winds for power generation.

In addition to these basic dimensioning questions, the correct selection of the control represents one of the most important factors associated with a wind generation station. The wind-wheel control has the task of preventing wind loads which are too large and which occur under storm conditions. Also the developed wind-wheel power must be adapted to the dynamo characteristic line when the wind velocities are above nominal. In small installations, the rotation rate can be limited by brake flaps (Figure 1) or by turning it out of the wind. This latter method is usually preferred. The wind-wheel is most easily turned out of the wind by using an eccentric control, which is a type of eclipse control system successfully used for wind turbines. This simple arrangement results in reliable protection against storm conditions, but it does not provide an accurate performance control, which is not necessary at all with the generators used today. The electrical control problems are caused by the behavior of shunt dynamos when run at varying rotation rates. When operated with a battery, the flat section of the shunt wound generator characteristic line and the battery characteristic line results in a considerable decrease in the charge current for the smallest changes in rotation rate of the dynamo or voltage changes from the battery. The current production installation in vehicles is subjected to similar difficult conditions as occur for a wind-wheel. This problem can be solved in an economical way by modifying the lighting installations for vehicles in a certain way. The same method can be applied to small wind generation installations. In addition, there are a number of advantages associated with low voltages.

In foreign countries, current controlled machines are preferred for light generation purposes in vehicles, which operate according to the three-brush method. Using the field distortion, the excitation winding is also influenced in a way such that the consumed current of the machine remains within certain limits. Such machines can only be used in conjunction with a battery (buffer operation). One distinct disadvantage of these machines is that they do not limit the charging process and can damage the battery because of overcharging.

On the other hand, when voltage control is used, as has been done by the firm Bosch and is almost exclusively used in Germany, the machine voltage is controlled according to the Tirill principle. One version has a voltage characteristic which decreases linearly with current intensity, a so-called yielding voltage characteristic. In this way the impressed charging current of the dynamos decreases slowly as the charge state increases, so that when the battery is full there is only a small harmless current load. This protects the battery from over charging but considerably increases the charging time. This factor is very important for wind operation, because the charging time must be set equal to the required hours of wind.

This disadvantage is overcome by a voltage control system with a broken characteristic line, which is used for larger light generation machines. Charging is carried out at a constant current intensity over almost the entire process and the charge is nevertheless automatically limited [3].

The characteristic line of the voltage controlled light machine shown in Figure 2 corresponds to the uncontrolled range of a normal shunt wound machine. During the beginning of the controlling process, that is when the maximum power level is reached, there is a sharp bend. Because of the nature of the control system, it drops off first of all somewhat, but does remain absolutely constant if the rotation rate increases further. The dynamo power does not exceed the permissible level even when it operates in conjunction with a wind-wheel, even though the wind-wheel could deliver somewhat higher power levels at higher wind velocities, due to the fact that there are inaccuracies in the control of the wind-wheel.

A number of important questions must be answered for the electrical part of wind generation stations for foreign countries, so that successful operational conditions can be achieved. Voltage losses in the lines, transmission through brushes, ignored temperature conditions in the controller and battery can all seriously endanger the charging operation [3]. Small wind electric installations should be planned for illumination and radial applications. The controller and the lines must be made free of disturbances. The construction must be "idiot proof", because the users cannot be expected to have sufficient knowledge.

The author developed a miniature wind generation station for lighting purposes according to the principles mentioned above which can satisfy the requirements of remote settlements (farmers). The three blade metal wind-wheel has a gear which is attached to a voltage controlled 24 V and 450 W dynamo. The operation is completely automatic and there is almost no maintenance. There is automatic storm control by the eccentricity control system. The installation can also be lowered with a pulley.

Operational Experience

The first installation has been in operation over several years and has satisfied the requirements completely. A battery is used during conditions of no wind, consisting of two 12-volt starter batteries of 150 Ah each. A number of 15, 25 and 36 W /160
bulbs as well as a three tube radio are supplied. The operation is quite economical and it is believed that the yearly costs are about 100 DM.

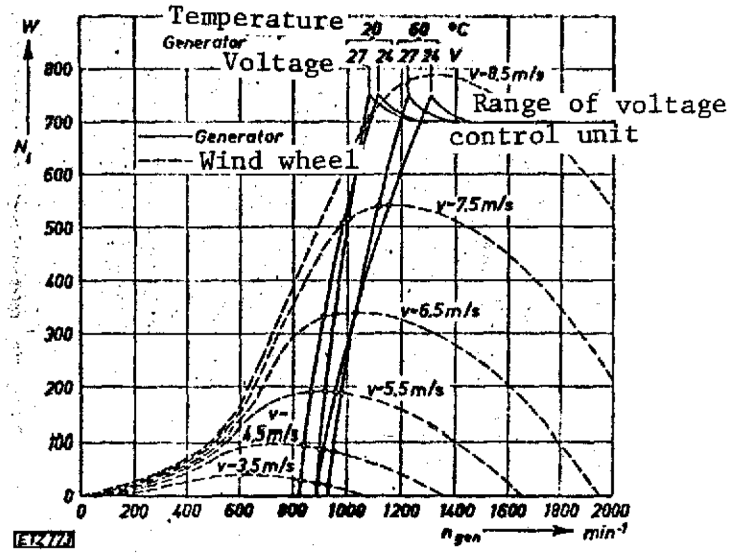

Figure 2. Characteristic line interaction between wind-wheel and dynamo of a twin wind generation station

Export Predictions

Recent inquiries from foreigners show us that the American industry is not at all even close to being able to satisfy the demand for small wind generation stations. As the efforts of a few firms have shown, the German industry should be able to export a qualified miniature wind power generation station and thereby increase the all important exports of Germany.

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